



Herpetofauna diversity in Zamrud National Park, Indonesia: baseline checklist for a Sumatra peat swamp forest ecosystem

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Abstract.—Sumatra is an island that contains rich wildlife biodiversity and a variety of ecosystems, and is categorized as one of the most threatened terrestrial ecoregions on earth. One of Sumatra's ecosystems is peat swamp forest, which has unusually extreme conditions, but otherwise can support diverse flora and fauna with many endemic and endangered species, including herpetofauna. This survey was conducted in Zamrud National Park (ZNP) with the goal of determining the herpetofaunal diversity and community. Visual encounter survey and glue trap methods were used to sample and determine species diversity and distributions. The survey identified 33 herpetofauna species in ZNP, which included 12 amphibian and 21 reptile species. *Cyrtodactylus majulah* was the most common species that could be found in all transects. The 33 species, or approximately 30.8% of all herpetofauna in Kampar Peninsular, were found in only 15 days of fieldwork, and included two high-risk species, i.e., *Limnonectes malesianus* (NT) and *Cuora amboinensis* (VU). Furthermore, two endemic Sumatra species, *Chalcorana parvaccola* and *Pulchrana rawa*, were also recorded, along with a new distribution record of a skink species for Sumatra and Indonesia. Further surveys and monitoring are needed to continue the inventory and to monitor the current communities, as well as to document new findings in other areas of ZNP.

Keywords. Amphibian, Asia, conservation, ecology, new record, reptile, wetland

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Introduction

Sumatra is the sixth largest island on earth, and it contains rich wildlife biodiversity and is home for several charismatic species. The island houses various ecosystems and is categorized as one of the most threatened terrestrial ecoregions on earth (Olson and Dinerstein 2002; Mittermeier et al. 2004). Zamrud National Park (ZNP), located in Riau Province, is the newest national park in Indonesia and was established on 22 July 2016. ZNP is dominated by primary peat swamps and peatland forest ecosystem, which cover areas spanning 31,480 ha, and includes two major lakes, Pulau Besar Lake and Bawah Lake.

Sumatra's forest ecosystem has been continuously threatened by habitat loss and deforestation. Riau Province, in particular, is the top province in Sumatra and Indonesia for major deforestation problems, due to land conversion into palm oil plantations, forest fires, and illegal logging (FWI 2014).

Peat swamp forest is an unusual ecosystem that differs dramatically from the other ecosystems of the world. It has extreme conditions of low pH, low nutrients, and an unstable and spongy substrate of peat that can be 20 m deep or more. The peat swamp forest in Sumatra can support diverse flora and fauna, including many endemic and endangered species. Disturbances in peat swamp forests may increase the impact of climate change on the

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Fig. 1. Peat swamp forest in Zamrud National Park.

biodiversity (Yule 2010; Posa et al. 2011).

Only limited biodiversity information is available for the peat swamp forests in the Indo-Malayan region, including ZNP, particularly on the amphibians and reptiles (Yule 2010). Environmental changes and climate change have become the biggest threats to biodiversity around the world. These changes can increase global temperatures, causing abnormal and extreme rainfall cycles, and will affect the metabolism of herpetofauna as they are ectothermic species. The increased temperatures, reduced precipitation and habitat loss could drive herpetofauna populations and species into extinction (Hansen et al. 2001; Bickford et al. 2010). Therefore, the reptiles and amphibians is the finest of the key bio-indicators for measuring the impact of climate change, because their current distributions and ecological niches closely reflect rainfall and temperature patterns (Bickford et al. 2010). This work documents the herpetofauna diversity and community in ZNP.

Material and Methods

Field Surveys

Zamrud National Park (previously named Pulau Besar Lake/Bawah Lake Wildlife Reserve) is part of the Kampar Peninsula and one of the important conservation areas in Riau Province. Dominated by peatland and peat swamp ecosystems (e.g., Fig. 1), ZNP and Kampar Peninsula are the habitats occupied by Sumatra's

widely-known endemic and charismatic species, such as Sumatran Tiger, Asian Arowana, hornbills, and certain herpetofauna. ZNP once spanned 28,237.95 ha, but was expanded to 31,480 ha in area after being designated as a national park in 2016. Currently, ZNP is surrounded by palm oil and industrial plantations and is threatened by petroleum mining which occurs inside the national park area. Spatial management and a precise conservation action plan are likely needed to protect the biodiversity within the national park area (WWF 2006; BLH Riau 2011).

A purposive sampling method was used to select the transects, by considering habitat conditions which represent the different environmental conditions found in ZNP. The survey sites were divided into seven transects, i.e., Bron 2 (B2), Shrubs Area (SA) across to Siak Resort (our basecamp), Besar Island (BI), Idris Well (IW), Sejuk Kanan Bawah Lake (SKaBL), Sejuk Kiri Bawah Lake (SKiBL), and Sejuk Atas Pulau Besar Lake (SAPBL) (Fig. 2). This survey was conducted for 15 days of fieldwork from 28 December 2017 to 18 January 2018.

Methods

The herpetofauna survey used standard Visual Encounter Survey methods, and the materials included headlamp, snake hook, grab stick, global positioning system (GPS) device, thermometer, hygrometer, sample pouch, measuring tape (50 m), pH meter, plastic pouch, notebook, digital camera, and watch. Specimen preservation ma-

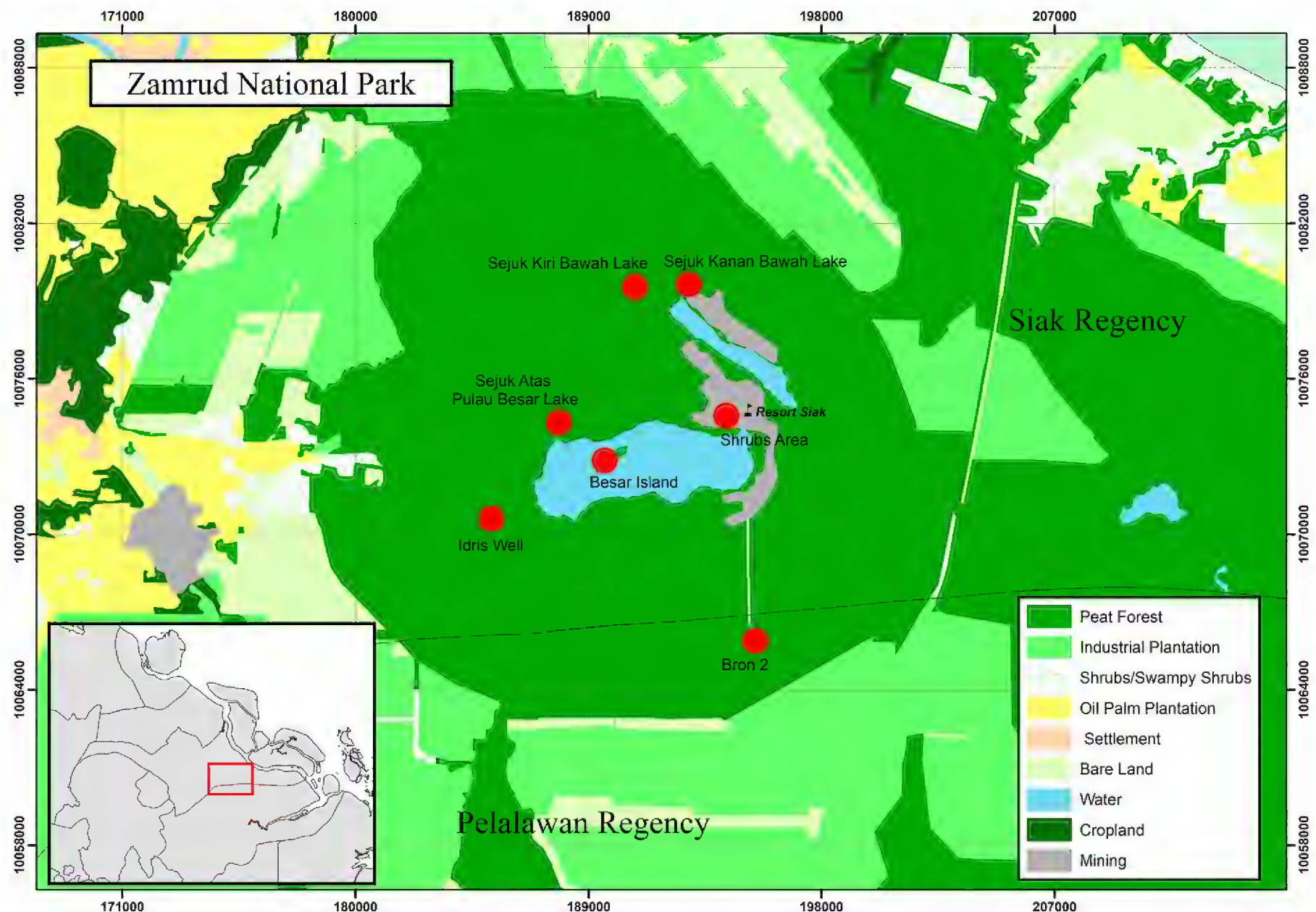


Fig. 2. Locations of the survey sites in Zamrud National Park.

materials consisted of formaldehyde (10%), ethanol (70% and 96%), ether, and other standard equipment. Following Heyer et al. (1994) and McDiarmid et al. (2012), the visual encounter survey was used to evaluate species richness, to compile the species list, and to calculate relative abundance, and it can be combined with other methods. The visual encounter survey method assessed 500 m length transects, so that species density could be measured within each sampling area. In each area, 1–3 transects were used, considering the habitat conditions and the availability of water sources (streams, swamps, or ponds). Only one transect was used in SA considering that it is an open area and lacks a water source, and 2–3 transects were used in other areas. The survey was conducted during 0700–0900 h and 1800–2100 h during each day. Passive methods were also used, such as the glue traps to catch fast and agile individuals like skinks, and to obtain more efficient estimations and reduce bias in the calculations. In addition, habitat and environmental parameters were collected for each transect, i.e., environmental temperature, pH, and humidity.

Specimen Collection and Identification

Following the guidelines from Pisani (1973) and Dodd (2016), specimens were collected as needed. The preservation process was conducted by following precise ethical standards and procedures. First, the specimen

was euthanized by ether, then dissected to obtain muscle or liver tissue samples. The samples were injected with formaldehyde (10%) and then posed precisely so that all morphological characters could be shown properly. The specimen was then labeled, drenched with formaldehyde (10%) and allowed to set for 2–3 days to allow the shape to properly form. All formed specimens were then preserved in 70% ethanol. All collected specimens (see **Appendix**) were then deposited at the Museum Zoologicum Bogoriense (MZB) LIPI. The identification process was carried out by comparing the characters of all collected specimens and photos with the key references following Kamsi et al. (2017), Das (2010), Frost (2020), and Uetz and Hallermann (2020).

Data Analysis

All of the statistical data were analyzed using Paleontological Statistics (PAST) version 2.17c (Hammer et al. 2001). Principal Component Analysis (PCA) was used to analyze the species composition according to habitat preferences.

Results

During the survey in ZNP, 33 herpetofauna species were identified, which comprised 12 amphibian and 21 reptile species (see photos of eight of the species in Fig. 3). The

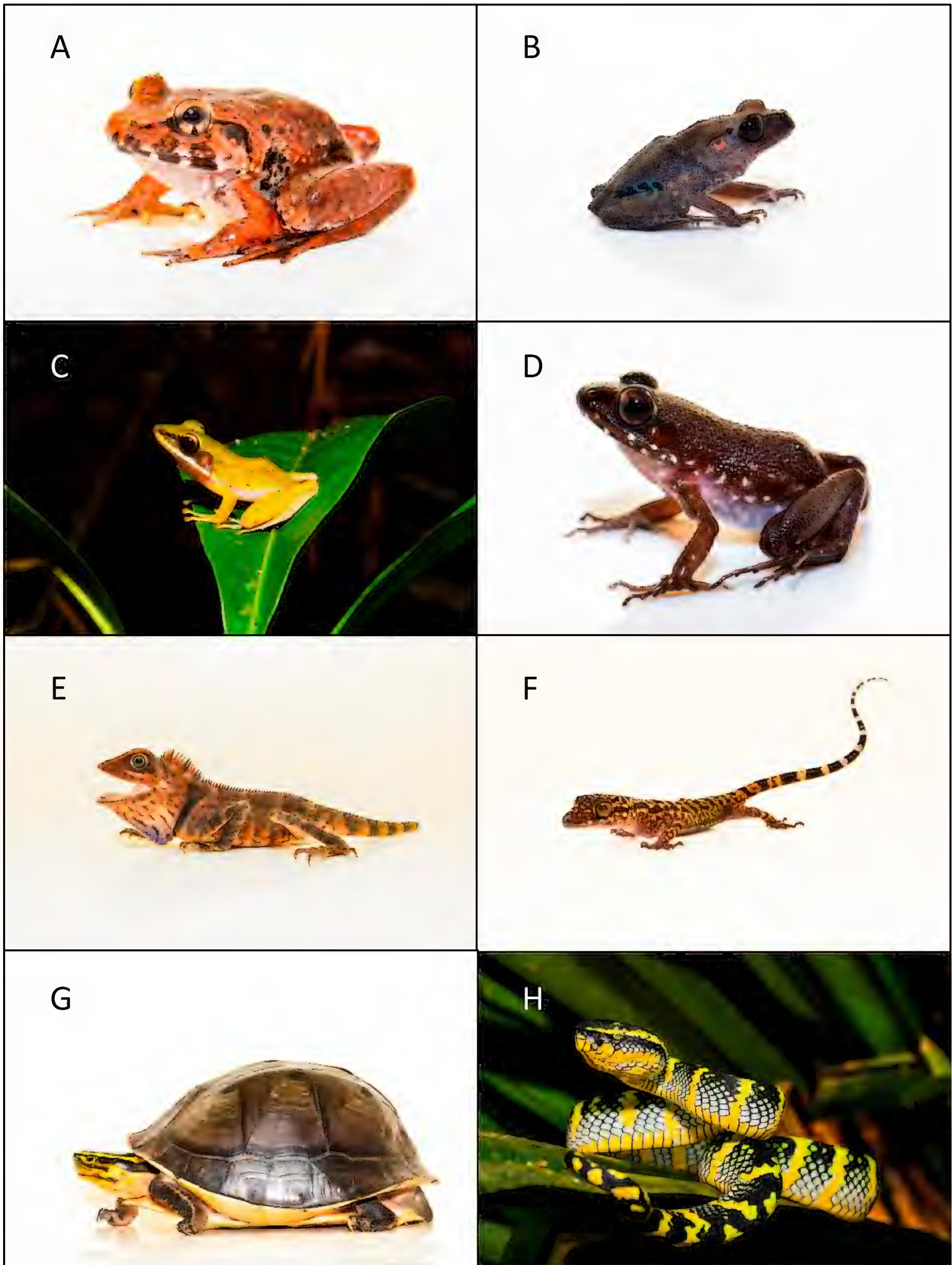


Fig. 3. Eight of the 33 species found in this survey. (A) *Limnonectes malesianus*; (B) *Leptobrachium nigrops*; (C) *Chalcorana parvaccola*; (D) *Pulchrana rawa*; (E) *Gonocephalus liogaster*; (F) *Cyrtodactylus majulah*; (G) *Cuora amboinensis*; (H) *Tropicodolaemus wagleri*.

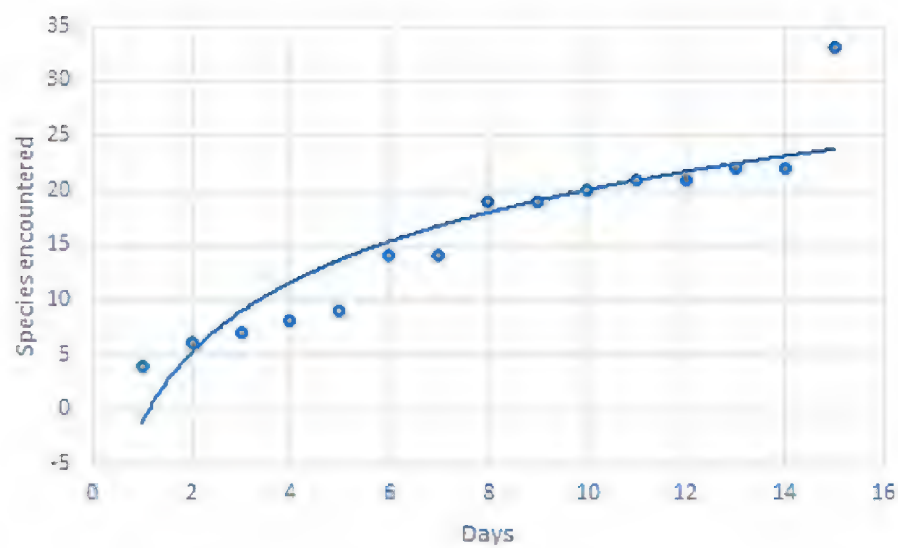


Fig. 4. Species accumulation curve illustrates the accumulation of the encountered species during the 15 days of field sampling.

33 species were found during the course of 15 days of fieldwork (Fig. 4). *Cyrtodactylus majulah* was the most common species that was found in all transects. Details for the recorded species are presented in Table 1 and the following Checklist.

Checklist

All of the species checklist descriptions were checked against the appropriate global databases, following Uetz and Hallermann (2020), Frost (2020), and AmphibiaWeb (2020). For each species, conservation status follows an assessment from the International Union for Conservation of Nature (IUCN 2020).

Amphibia

Family Bufonidae

1. *Ingerophrynus quadruporcatus* (Boulenger, 1887)

Common name: Four-ridged Toad, Greater Malacca Toad, Swamp Toad.

Distribution and habitat: Peninsular Malaya, Singapore, Borneo, Natuna Island, and Sumatra. This species commonly lives in peat swamp areas near coastal lowlands.

Conservation status: Least Concern.

2. *Pseudobufo subasper* Tschudi, 1838

Common name: False Toad.

Distribution and habitat: Sumatra, Borneo, and Peninsular Malaya. This fully aquatic species inhabits peat swamps or swamp forests.

Conservation status: Least Concern.

Family Dicroglossidae

3. *Limnonectes malesianus* (Kiew, 1984)

Common name: Singapore Wart Frog, Malesian Frog, Malaysian Peat Frog, Malaysian River Frog.

Distribution and habitat: Peninsular Malaya, Southern Peninsular Thailand, West Malaysia, Singapore, Suma-

tra, Java, Borneo, Kundur Island, Galang Island, Great Natuna Island, and Singkep Island. This species inhabits shallow, gentle streams, and nearby swampy areas including peat swamps and very flat alluvial forests, including primary and secondary forests.

Conservation status: Near Threatened.

Family Megophryidae

4. *Leptobrachium nigrops* Berry and Hendrickson, 1963

Common name: Singapore Spadefoot Toad, Black-eyed Litter Frog.

Distribution and habitat: Peninsular Malaya, Singapore, and Sumatra. This species is commonly found amongst the leaf litter in primary or secondary forest, and also in suitable wetlands and peat swamp forests.

Conservation status: Least Concern.

Family Ranidae

5. *Chalcorana parvaccola* (Inger, Stuart, and Iskandar, 2009)

Common name: Kongkang Kecil (Indonesian).

Distribution and habitat: Previously listed as endemic to Sumatra, known only from West Sumatra, Indonesia. However, this inventory of ZNP revealed an expansion of the distribution from West Sumatra to Riau. This species occupies a wide altitude range from 30 to 1,500 m asl. This frog is also commonly found in primary or secondary forest among small creeks, and also in suitable peat swamp forest and wetland ecosystems.

Conservation status: Least Concern.

6. *Fejervarya limnocharis* (Gravenhorst, 1829)

Common name: Indian Cricket Frog, Boie's Wart Frog, Grass Frog, Field Frog, Rice Frog, Paddy Frog, Cricket Frog, Terrestrial Frog, White-lined Frog, Ricefield Frog, Paddy Field Frog.

Distribution and habitat: This species has a widespread distribution from South and East Asia to Southeast Asia. In Indonesia, this species is distributed in Sumatra, Borneo, Java, and Sulawesi, and is highly adapted to many different kinds of ecosystems. It is commonly found in forest, grassland, savanna, wetlands, and artificial ecosystems, such as paddy fields and urban areas.

Conservation status: Least Concern.

7. *Hylarana erythraea* (Schlegel, 1837)

Common name: Red-eared Frog, Golden-lined Frog, Green Paddy Frog, Common Greenback, Green Lotus Frog, Green-backed Frog, Common Green Frog.

Distribution and habitat: This species is widely distributed from South Asia (India, Bangladesh, and Sri Lanka) to throughout the Southeast Asia region. In Indonesia, its distribution includes Sumatra, Borneo, Java, and Lesser Sunda Island. The species has also been reported as introduced to the Philippines and Sulawesi Island (Indonesia).

Table 1. Herpetofauna species encountered during the survey. Site codes: Bron 2 (B2), Shrubs Area (SA) across to Siak Resort (our basecamp), Besar Island (BI), Idris Well (IW), Sejuk Kanan Bawah Lake (SKaBL), Sejuk Kiri Bawah Lake (SKiBL), and Sejuk Atas Pulau Besar Lake (SAPBL).

No.	Species	B2	SA	BI	IW	SKaBL	SKiBL	SAPBL	Outside Transect
Amphibians									
1	<i>Chalcorana parvaccola</i>			√			√	√	
2	<i>Fejervarya limnocharis</i>								√
3	<i>Hylarana erythraea</i>								√
4	<i>Ingerophrynus quadriporcatus</i>					√	√	√	
5	<i>Leptobrachium nigrops</i>					√			
6	<i>Limnonectes malesianus</i>					√	√	√	
7	<i>Polypedates colletti</i>	√					√		
8	<i>Polypedates leucomystax</i>				√				
9	<i>Polypedates macrotis</i>	√	√		√		√		
10	<i>Pseudobufo subasper</i>			√					√
11	<i>Pulchrana baramica</i>	√	√			√	√	√	
12	<i>Pulchrana rawa</i>	√				√	√	√	
Reptiles									
13	<i>Ahaetulla prasina</i>				√				
14	<i>Aphaniotis fusca</i>				√	√	√	√	
15	<i>Boiga dendrophila</i>								√
16	<i>Coelognathus flavolineatus</i>								√
17	<i>Cuora amboinensis</i>								√
18	<i>Cyrtodactylus majulah</i>	√	√	√	√	√	√	√	
19	<i>Dasia olivacea</i>				√				
20	<i>Dendrelaphis caudolineatus</i>		√					√	
21	<i>Dendrelaphis formosus</i>						√		
22	<i>Enhydryis enhydryis</i>								√
23	<i>Eutropis multifasciata</i>						√	√	
24	<i>Gonocephalus liogaster</i>	√					√		
25	<i>Hemidactylus frenatus</i>								√
26	<i>Hemiphyllodactylus typus</i>								√
27	<i>Homalopsis buccata</i>								√
28	<i>Lycodon subannulatus</i>							√	
29	<i>Lygosoma samajaya</i>				√				
30	<i>Malayopython reticulatus</i>								√
31	<i>Sphenomorphus cyanolaemus</i>					√			
32	<i>Tropidolaemus wagleri</i>					√		√	
33	<i>Varanus salvator</i>								√

It inhabits small ponds, creeks, and streams with floating marsh vegetation or bushes. This frog is also found in suitable artificial ecosystems, such as paddy fields and urban areas.

Conservation status: Least Concern.

8. *Pulchrana baramica* (Boettger, 1900)

Common name: Masked Rough-sided Frog, Baram River Frog, Baram's Frog, Masked Frog, Brown Marsh Frog.

Distribution and habitat: Extreme southern peninsular Thailand and Malaya, Java, Borneo, Sumatra, Singapore, and Bangka Island. This species inhabits alluvial and peat swamp forests. It is also known to dwell in lowland

floodplains and lowland swampy forests.

Conservation status: Least Concern.

9. *Pulchrana rawa* (Matsui, Mumpuni, and Hamidy, 2012)

Common name: Kongkang Rawa (Indonesian).

Distribution and habitat: Endemic to Sumatra. So far, this species is only known from several locations in Riau and South Sumatra Province. One observation shows this species also occurs in Sambas Regency, West Kalimantan Province. However, its presence in Kalimantan is in doubt, since it has not been confirmed elsewhere in Kalimantan. This species specifically inhabits the peat swamp forests.

Conservation status: Least Concern.

Family Rhacophoridae

10. *Polypedates colletti* (Boulenger, 1890)

Common name: Collett's Whipping Frog, Black-spotted Tree Frog, Collett's Tree Frog.

Distribution and habitat: Peninsular Thailand and Malaya, Sumatra, Borneo, Natuna Islands, various islands in The South China Sea, and Southern Vietnam. This species can be found in lowland primary or secondary forest, disturbed forest, swampy forest, and peat swamp forest. The altitude ranges from coastal up to 600 m asl.

Conservation status: Least Concern.

11. *Polypedates leucomystax* (Gravenhorst, 1829)

Common name: Java Whipping Frog, Common Tree Frog, Brown Tree Frog, Malayan House Frog, Four-lined Tree Frog, White-lipped Tree Frog, Malayan Tree Frog, Bamboo Tree Frog, House Tree Frog, Jar Tree Frog, Stripe Tree Frog, Asia Brown Tree Frog, Golden Tree Frog.

Distribution and habitat: Eastern India, Nepal, Myanmar, Southern China, throughout South East Asia, Philippines, Sumatra, Borneo, Java, Sulawesi, Lesser Sunda Islands, and the Moluccas. Introduced to Papua and Japan (Southern Ryukyus). This species inhabits both wetlands and forests, is adaptable in urban settings, and can be found in garden ponds, buildings, and on roads.

Conservation status: Least Concern.

12. *Polypedates macrotis* (Boulenger, 1891)

Common name: Baram Whipping Frog, Forest Bush Frog, Dark-eared Tree Frog, Bongao Bubble-nest Frog.

Distribution and habitat: Peninsular Malaya, Thailand, Sumatra, Mentawai Island, Natuna Islands, Borneo, and Southwestern Philippines. This species generally inhabits primary forest and edge areas, also found in suitable wetlands and artificial habitats, such as canals and drainage channels. It has been recorded up to 1,250 m asl.

Conservation status: Least Concern.

Reptilia

Family Agamidae

13. *Aphaniotis fusca* (Peters, 1864)

Common name: Dusky Earless Agama, Peninsular Earless Agama.

Distribution and habitat: Southern Thailand, Peninsular Malaya, West Malaysia, Singapore, Tioman Island, Johor, Sumatra, Nias, Singkep, Borneo, and Natuna Islands. This species inhabits primary and lightly disturbed lowland moist forests and mid-hills, including dipterocarp forests and peat swamp forests.

Conservation status: Least Concern.

14. *Gonocephalus liogaster* (Günther, 1872)

Common name: Tropical Forest Dragon, Blue-eyed Angle Head Lizard, Orange-ringed Angle Head Lizard.

Distribution and habitat: West Malaysia, Sumatra, Natuna Islands, and Borneo. This species inhabits lowland primary forest (up to 400 m asl) and peat swamp forest, and appears to be encountered more frequently near forest streams.

Conservation status: Not known.

Family Colubridae

15. *Ahaetulla prasina* (Boie, 1827)

Common name: Gunther's Whip Snake, Oriental Whip Snake, Asian Vine Snake, Jade Vine Snake.

Distribution and habitat: China (*A. p. medioxima*), Philippines (*A. p. preocularis*), Philippines and Sulu Archipelago (*A. p. suluensis*), South Asia (India, Bangladesh, Sri Lanka, Andaman, and the Nicobar Islands), and throughout Southeast Asia. In Indonesia, this species is widely distributed in Sumatra, Borneo, Java, Sulawesi, and the Lesser Sunda Islands. This snake inhabits both primary lowland and montane moist forests, secondary forests, open and dry forests, disturbed forest, scrublands, plantations, as well as city gardens and urban areas. Commonly found from sea level up to 1,300 m asl.

Conservation status: Least Concern.

16. *Boiga dendrophila* (Boie, 1827)

Common name: Gold-ringed Cat Snake, Mangrove Snake, Yellow-ringed Cat Snake.

Distribution and habitat: Throughout Southeast Asia from Myanmar to Indonesia. In Indonesia, this species is distributed in Sumatra, Borneo, Java, and Sulawesi. It inhabits lowland forests, including mangrove swamps and peat swamp forests, at elevations from sea level up to 700 m asl.

Conservation status: Not known.

17. *Coelognathus flavolineatus* (Schlegel, 1837)

Common name: Black Copper Rat Snake, Yellow-striped Snake, Yellow-striped Trinket Snake.

Distribution and habitat: India, Myanmar, Thailand, Vietnam, Cambodia, Peninsular Malaya, Singapore, Sumatra, Borneo, Java, Bali, and Sulawesi. This species inhabits primary and secondary forests, disturbed forests, and urban areas, at elevations from sea level up to 1,000 m asl.

Conservation status: Least Concern.

18. *Dendrelaphis caudolineatus* (Gray, 1834)

Common name: Gray Bronze Back, Striped Bronze Back.

Distribution and habitat: Sri Lanka (*D. c. effrenis*), Thailand, Peninsular Malaya, Singapore, Sumatra, and Borneo. This arboreal species occurs in lowland forests, open secondary growth vegetation, and scrubland. It also can be found in urban areas, such as gardens and parks.

Conservation status: Not known.

19. *Dendrelaphis formosus* (Boie, 1827)

Common name: Elegant Bronze Back, Beautiful Bronze Back Tree Snake.

Distribution and habitat: Thailand, Peninsular Malaya, Singapore, Sumatra, Borneo, Mentawai Archipelago, Riau Archipelago, and Java. This species occurs in lowland forest, scrubland, alluvial forest, heath forest, peat swamp forest, and in gardens within villages. It has been encountered from sea level up to 600 m asl.

Conservation status: Least Concern.

20. *Lycodon subannulatus* (Duméril, Bibron, and Duméril, 1854)

Common name: Malayan Bridal Snake, Southern Bridle Snake, Half-banded Bridled Snake, Brown-saddled Tree Snake.

Distribution and habitat: Myanmar, Thailand, Malaysia, Philippines, Singapore, Sumatra, and Borneo. This arboreal species is commonly found in lowland forests and disturbed areas, at altitudes ranging from sea level to about 900 m asl.

Conservation status: Least Concern.

Family Gekkonidae

21. *Cyrtodactylus majulah* Grismer, Wood, and Lim, 2012

Common name: Singapore Bent-toed Gecko.

Distribution and habitat: Singapore, Bintan Island, and probably expanded to Riau Province in Sumatra (as recorded in this survey). This species occurs in lowland forests, specifically freshwater swamp forests, and also peat swamp forests.

Conservation status: Not known.

22. *Hemidactylus frenatus* Duméril and Bibron, 1836

Common name: Chichak, Common House Gecko, South Asian House Gecko, Bridled House Gecko, Asian House Gecko, Spiny-tailed House Gecko.

Distribution and habitat: This species is distributed worldwide in tropical and subtropical regions. It is native in Southern and Southeast Asia, and in the Indo-Australian Archipelago. It inhabits man-made dwellings, cities, villages, and also forested areas among boulders, trees, or logs; and at altitudes ranging from sea level to about 1,600 m asl.

Conservation status: Least Concern.

23. *Hemiphyllodactylus typus* Bleeker, 1860

Common name: Tree Gecko, Indopacific Slender Gecko, Common Dwarf Gecko, Lowland Dwarf Gecko, Worm Gecko.

Distribution and habitat: China, Taiwan, India, Sri Lanka, throughout Southeast Asia, Philippines, Sumatra, Java, Borneo, Lesser Sunda, Sulawesi, New Guinea, and Oceania, introduced to Japan and Hawaii. This species inhabits lowland forests and mangroves, up to an altitude of nearly 1,000 m asl.

Conservation status: Not known.

Family Geoemydidae

24. *Cuora amboinensis* (Daudin, 1802)

Common name: Amboina Box Turtle, Southeast Asian Box Turtle, Malayan Box Turtle, Indonesian Box Turtle, Burmese Box Turtle, Malayan Box Terrapin.

Distribution and habitat: India, Bhutan, Bangladesh, Myanmar, Thailand, Cambodia, Vietnam, West Malaysia, Singapore, Philippines, Sumatra, Borneo, Java, Sulawesi, Lesser Sunda, and Mollucas. This species inhabits slow-flowing water bodies, including rivers, lakes, marshes, peat swamps, and mangrove swamps, as well as agricultural areas.

Conservation status: Vulnerable.

Family Homalopsidae

25. *Enhydris enhydris* (Schneider, 1799)

Common name: Rainbow Mud Snake, Rainbow Water Snake, Striped Water Snake, Smooth Water Snake.

Distribution and habitat: Nepal, India, Bangladesh, Sri Lanka, Myanmar, Thailand, Vietnam, Cambodia, Malaysia, Singapore, Sumatra, Java, Borneo, and Sulawesi. This species inhabits freshwater habitats, including slow-moving streams, canals, marshes, ricefields, and sometimes brackish water areas.

Conservation status: Least Concern.

26. *Homalopsis buccata* (Linnaeus, 1758)

Common name: Linne's Water Snake, Puff-faced Water Snake, Masked Water Snake.

Distribution and habitat: Bangladesh, Myanmar, Thailand, Cambodia, Vietnam, Laos, Malaysia, Singapore, Sumatra, Borneo, Java, and Sulawesi. This freshwater species inhabits slow-moving and stagnant waterways, such as swamps, ponds, and ricefields.

Conservation status: Least Concern.

Family Pythonidae

27. *Malayopython reticulatus* (Schneider, 1801)

Common name: Reticulated Python.

Distribution and habitat: Bangladesh, India (Nicobar Island), Myanmar, Thailand, Vietnam, Laos, Cambodia, Philippines, Peninsular Malaya, Sumatra, Java, Borneo, Sulawesi, Lesser Sunda Islands, and Mollucas. This species can be found in various ecosystems such as primary forests, secondary forests, savannas, wetlands, scrublands, marshes, peat swamp forests, mangrove swamps, grasslands; and also in disturbed areas, such as agricultural areas and urban areas. It has been found from sea level to about 1,300 m asl.

Conservation status: Least Concern.

Family Scincidae

28. *Dasia olivacea* Gray, 1839

Common name: Olive Dasia, Olive Tree Skink.

Distribution and habitat: India (Nicobar Island), Myanmar, Thailand, Laos, Vietnam, Cambodia, Philippines, Peninsular Malaya, Sumatra, Java, Borneo, and Bali. This species inhabits coastal, lowland forests, peat swamp forests, and other forests up to 1,200 m asl.

Conservation status: Least Concern.

29. *Eutropis multifasciata* (Kuhl, 1820)

Common name: Common Mabuya, Many-lined Sun Skink, East Indian Brown Mabuya, Common Sun Skink, Javan Sun Skink.

Distribution and habitat: India, Bangladesh, China, Taiwan, Myanmar, Thailand, Laos, Cambodia, Vietnam, Peninsular Malaya, Singapore, Borneo, Sumatra, Java, Bali, Komodo Island, Flores, Sulawesi, Halmahera, Timor-Leste, New Guinea, and the Philippines. This species occupies a wide range of habitats including tropical dry, moist lowland and montane forest, savannah, woodland, peat swamp forest, eucalyptus forest, coffee plantations, agricultural land, disturbed riparian habitats, gardens, and village land. It is found at elevations up to 1,800 m asl.

Conservation status: Least Concern.

30. *Lygosoma samajaya* Karin, Freitas, Shonleben, Grismer, Bauer, and Das, 2018

Common name: None.

Distribution and habitat: Malaysia (Sarawak) as the type locality. The current survey revealed a new distribution record for this species in Riau Province, Sumatra. This species specifically dwells in heath forests, dipterocarp forests, and peat swamp forests. It is also presumed as a semi-fossorial species as suggested by its elongate morphology.

Conservation status: Not known.

31. *Sphenomorphus cyanolaemus* Inger and Hosmer, 1965

Common name: Blue-headed Forest Skink, Blue-throated Litter Skink.

Distribution and habitat: Peninsular Malaya, Sumatra, and Borneo. This species inhabits lowland rainforest up to 850 m asl. This slender-bodied skink largely remains on the forest floor, searching amongst leaf litter for its prey; but is also known to climb short distances up tree trunks. It probably feeds on forest floor insects.

Conservation status: Least Concern.

Family Varanidae

32. *Varanus salvator* (Laurenti, 1768)

Common name: Common Water Monitor.

Distribution and habitat: Sri Lanka, India, Bangladesh, Myanmar, Cambodia, Laos, Vietnam, China, Thailand, Malaysia, Singapore, and Indonesia (Borneo, Sumatra, Nias, Enggano, Bangka, Kalimantan, Java, Bali, Lombok, Sumbawa, Flores, Wetar, and Sulawesi). This species is frequently seen on river banks and in swamps.

Conservation status: Least Concern.

Family Viperidae

33. *Tropidolaemus wagleri* (Boie, 1827)

Common name: Wagler's Keeled Green Pit Viper, Wagler's Palm Pit Viper, Wagler's Pit Viper, Temple Pit Viper.

Distribution and habitat: Indonesia (Sumatra), Malaysia (Peninsular Malaya), Singapore, Thailand, and Vietnam. This species is perhaps the commonest pit viper in Southeast Asia. It occurs in lowland forests, either primary or secondary, and in some coastal regions it may occur in mangroves. It occurs at elevations up to 400 m asl.

Conservation status: Least Concern.

General Observations

The differences in the environmental conditions of each survey area may influence the species distribution and habitat preferences of herpetofauna in ZNP. Overall, the air temperature during the survey ranged between 26.2 and 28.9 °C, and the water temperature ranged between 23.4 and 28 °C. The complete set of environmental parameters is presented in Table 2.

The survey areas were grouped based on the presence of water bodies, e.g., rivers, streams, or lakes. The areas of Bron 2, the Shrubs Area, and Idris Well have drier habitats than Sejuk Kanan Bawah Lake, Sejuk Kiri Bawah Lake, and Sejuk Atas Pulau Besar Lake, while Besar Island is isolated and located in the middle of Pulau Besar Lake. Based on the findings of the survey, the herpetofauna species were mostly distributed near the water bodies, such as rivers or streams. Besar Island had the lowest number of herpetofauna species, which may be caused by its isolation from the mainland.

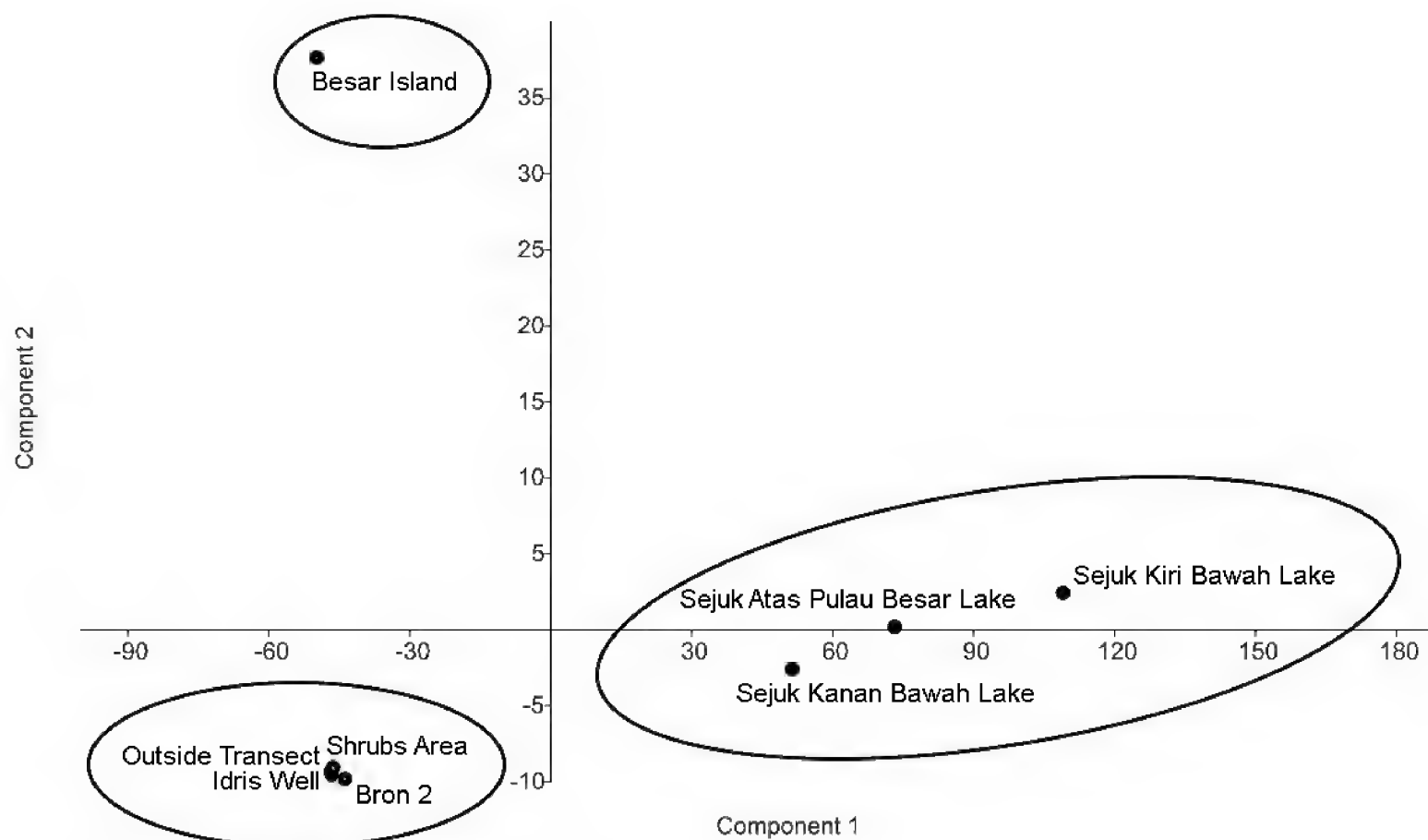


Fig. 5. Principal Component Analysis (PCA) of the distribution of herpetofauna species.

The PCA analysis used the species composition and the number of individuals encountered in each sampling point as the variables. That analysis shows that the distribution of herpetofauna species separated into three groups related to habitat preferences (Fig. 5). The resulting use variance-covariance matrix shows the variance percentage of the eigenvalue for PC 1 is 91.997%, and for PC 2 it is 5.336%. Besar Island is an isolated area; while Sejuk Kiri Bawah Lake, Sejuk Atas Pulau Besar Lake and Sejuk Kanan Bawah Lake are the areas with water bodies; and the Shrubs Area, Bron 2, Idris Well and outlying transects are the areas that are far from water bodies.

The environmental parameters show the differences between dry and wet habitat conditions. The data in Table 2 show that dry areas have higher air temperatures (27.6–28.9 °C) than wet areas (26.2–27.2 °C), and dry areas also have more humidity (91.3 to 95.9%) than wet areas (87.8 to 92.1%).

This survey found one individual of the recently described species *Lygosoma samajaya* Karin, Freitas, Shonleben, Grismer, Bauer, and Das, 2018 (Fig. 6), so

this observation represents a new record distribution for Sumatra and for Indonesia. The individual was collected on the glue trap board and photos were taken immediately after the specimen was cleaned. While it was described as a new species in early 2018, thus far it has only been recorded in Western Sarawak, Borneo, Malaysia. The specimen found in this survey was identified by comparing key characteristics to the holotype description. The ZNP specimen has uniform brown coloration on the dorsal surface of head, body, limbs, and tail; bright yellow coloration on the ventral surface of the head and body, and cream coloration on the ventral surface of limbs and tail. A light brown lateral stripe extends from the nostril through the eye, and fades in the halfway point between the limbs. Furthermore, the ZNP specimen has scale counts which match with the holotype description: quinquecarinate keeled dorsal and ventral scales; 7 supralabials; 5th below the eye; and 6 infralabials. The most important character that distinguishes *L. samajaya* from the other congeners is an interparietal scale with pineal eyespot in the posterior margin. Further measurements can be obtained by examining the specimen deposited in MZB (see **Appendix**).

Table 2. Environmental parameters for each survey area.

Survey Areas	Air Temperature (°C)	Water Temperature (°C)	Humidity (%)	pH	
				Water	Soil
Bron 2	27.6	27.7	95.9	4.3	3.3
Shrubs Area	28.7	28	92.2	4	3.5
Besar Island	28.5	27.9	92.5	4.2	2.8
Idris Well	28.9	-	91.3	-	3
Sejuk Kanan Bawah Lake	26.2	23.4	89	4.6	2.9
Sejuk Kiri Bawah Lake	27.1	24.6	87.8	4.6	3.8
Sejuk Atas Pulau Besar Lake	27.2	25	92.1	4	3.8



Fig. 6. Photos of specimen of *Lygosoma samajaya* Karin, Freitas, Shonleben, Grismer, Bauer, and Das, 2018 encountered in Zamrud National Park, Riau, Indonesia.

Discussion

Zamrud National Park is one of the finest places which represent the Sumatra peat swamp ecosystem (Fig. 1) and its biodiversity, including the herpetofauna diversity. It is one of the protected areas in Sumatra comprised of pristine, primary peat swamp forest. The Sumatra peat swamp ecosystem is the habitat for at least 135 reptiles and 42 amphibians, and these counts will undoubtedly increase as more explorations are conducted and new species are discovered (Das and van Dijk 2013). However, the size of the remaining pristine peat swamp forest in Indonesia has been decreasing dramatically due to many threats, e.g., illegal logging, drainage, agricultural conversion, petroleum mining, and development (Yule 2010; Posa et al. 2011). Despite such threats, the peat swamp forests are also becoming refuges for globally significant species from other lowland forests (Yule 2010).

As part of Kampar Peninsula, most of the biodiversity in ZNP also represents the biodiversity in Kampar Peninsula that is threatened by concessions, plantations, petroleum minings, and the widening of rivers. Recent surveys have recorded 107 species of herpetofauna (22 species of amphibians and 85 species of reptiles) in the whole area of Kampar Peninsula, and this survey found 33 species (or approximately 30.8% of all herpetofauna in Kampar Peninsula) within only 15 days of fieldwork (Fig. 4). Some endangered herpetofauna species not

found in this survey have been recorded in Kampar Peninsula, i.e., *Batagur borneoensis* (CR), *Heosemys spinosa* (EN), *Orlitia borneensis* (EN), *Pelochelys cantorii* (EN), *Manouria emys* (EN), *Tomistoma schlegelii* (VU), *Ophiophagus hannah* (VU), *Cuora amboinensis* (VU), *Siebenrockiella crassicollis* (VU), and *Amyda cartilaginea* (VU) [RER-FFI 2016].

The *L. samajaya* holotype was found in Sama Jaya Forest Reserve that includes heath and peat swamp forest ecosystems, surrounded by settlements. In this survey, the *L. samajaya* individual was found in peatland forest, suggesting that habitat is consistent with the new species habitat preferences. We assume that *L. samajaya* can only be found in peat swamp forest, heath forest, and lowland forest which are widely distributed in Sumatra and Kalimantan. Specifically, *L. samajaya* seems to select dense ground leaf litter and closed canopy forest as its habitat as a semi-fossorial species, and is able to survive in disturbed forest areas (Karin et al. 2018).

Herpetofauna species communities commonly select lower temperature and humidity conditions as their suitable habitat. As ectothermic creatures, herpetofauna species cannot regulate their own body temperature and must rely on their surrounding temperature and conditions. When their habitat becomes warmer, only some species are able to adapt and survive in such conditions. We assume that once the global temperature rises due to climate change, most herpetofauna species diversity will

decrease and some will go to extinction (Bickford et al. 2010).

The presence of water bodies is also significant for most amphibian populations to lay their eggs and breed. Reptile populations will follow amphibian population fluctuations because of their role as predators in the food chain (Vitt and Caldwell 2009). As an isolated site, Besar Island was the area with the least species diversity due to reduced possibilities for migration from Besar Island to the mainland (Whittaker and Fernandez-Palacios 2007).

Two of the species recorded have high-risk conservation status, i.e., *Limnonectes malesianus* (NT, van Dijk et al. 2004) and *Cuora amboinensis* (VU, Asian Turtle Trade Working Group 2000). Furthermore, two Sumatra endemic species were recorded, i.e., *Chalcorana parvaccola* (Inger et al. 2009) and *Pulchrana rawa* (Matsui et al. 2012). Further surveys of herpetofauna diversity, ecology, and distribution in ZNP are needed considering that the species accumulation curve (Fig. 4) indicates this short-term pilot survey was probably not sufficient to represent the full herpetofaunal diversity in the larger Sumatra Peat Swamp Forest Ecosystem.

Conclusion

A cursory survey of Zamrud National Park in Indonesia yielded 33 herpetofauna species, including 12 amphibians and 21 reptiles, with most found near water bodies. However, these findings are still insufficient to represent the herpetofauna communities in the whole area of ZNP. Further surveys and monitoring are needed to continue the inventory and to monitor the current communities in light of future threats, as well as the possibility of recording new findings in other areas of ZNP.

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Sandy Leo is a young biologist and environmentalist, interested in applying the diversity of terrestrial fauna (including herpetofauna) and their ecology to environmental studies. He received a grant from the National Geographic Society and conducted this fieldwork as a young explorer grantee. After graduating from the Department of Biology, the University of Indonesia in 2016, he has worked on various projects conducting surveys of Indonesian biodiversity (primates, herpetofauna, insects) and restoring peat swamp forest in Central Kalimantan. Currently, Sandy is in the master's program at the School of Environmental Science, the University of Indonesia, with sustainable development as his major.



Muhammad Suherman is a field researcher with extensive experience with herpetofauna, insects, and wildlife ecology. Muhammad has conducted many field studies, including an inventory of butterflies and dragonflies in Depok, West Java (ongoing); inventory of butterflies in Bawean Island Wildlife Reserve, East Java (2017); inventories of herpetofauna in Ujung Kulon National Park, Banten (2013); Mount. Ciremai National Park, West Java (2016); Batu Mentas Natural Recreation Park, Belitung Island (2018); and research on vector-borne disease reservoirs (bats and rats) in South Sulawesi (2017).



Anggi Permatasari graduated from the Biological Sciences major at Pakuan University (Indonesia) in 2016. After graduating she became interested in the field of herpetology. In 2018, she worked as an administrative staff member at CBD (Convention on Biological Diversity)-LIPI (Indonesian Institute of Sciences), and now she is active in the association of Amfibi Reptil Sumatra.



Darwan Suganda recently graduated from the Department of Forestry, the University of Riau (Indonesia) in early 2019. Since 2016, Darwan has been involved in many biodiversity surveys in Riau Province and he was a local volunteer in this Zamrud National Park herpetofauna expedition. He learned many new things during this project regarding the importance of herpetofauna and ecological survey methods.



Zulamri recently graduated from the Department of Biology, the University of Riau in early 2019. As a student, Zulamri participated in several organizations, such as Faculty of Mathematics and Natural Sciences Student Executive Board, Departement of Biology Student Association, WWF-Earth Hour Pekanbaru, and River Ambassador. He was a local volunteer in this Zamrud National Park herpetofauna expedition, and has been an intern in the WWF-Indonesia (WWF-ID) Central Sumatra Program.



Nurul L. Winarni has been working as a field biologist for years on a wide variety of field research projects, from observing game animals to birds, primates, and butterflies, particularly in Lampung and Buton, South-east Sulawesi, Indonesia. Nurul graduated in Biology, FMIPA, University of Indonesia, obtained a master's degree from the Warnell School of Forest Resources, University of Georgia (USA), and finished her Ph.D. at Manchester Metropolitan University (United Kingdom). Her studies have mainly focused on bird population dynamics, the community ecology of birds and butterflies (particularly the effect of anthropogenic disturbance on bird and butterfly communities), as well as evaluating the use of bird and butterfly species as indicators of disturbance. She is also interested in biodiversity monitoring and survey methodology, research design, and analysis. In the context of climate change, Nurul has been studying the impact of climate change on phenological patterns of tropical rainforest trees and the responses of biodiversity to climate change.

Appendix. List of specimens deposited in *Museum Zoologicum Bogoriense* (MZB)

Chalcorana parvaccola: MZB.Amph.31126, MZB.Amph.31127, MZB.Amph.31128, MZB.Amph.31129
Ingerophrynus quadriporcatus: MZB.Amph.31137, MZB.Amph.31138
Leptobrachium nigrops: MZB.Amph.31136
Limnonectes malesianus: MZB.Amph.31130, MZB.Amph.31131, MZB.Amph.31132
Polypedates colletti: MZB.Amph.31141, MZB.Amph.31142, MZB.Amph.31143
Polypedates macrotis: MZB.Amph.31139, MZB.Amph.31140
Pulchrana baramica: MZB.Amph.31133, MZB.Amph.31134, MZB.Amph.31135
Pulchrana rawa: MZB.Amph.31122, MZB.Amph.31123, MZB.Amph.31124, MZB.Amph.31125
Ahaetulla prasina: MZB.Ophi.6163
Aphaniotis fusca: MZB.Lace.14497, MZB.Lace.14498
Cyrtodactylus majulah: MZB.Lace.14494, MZB.Lace.14495, MZB.Lace.14496
Dasia olivacea: MZB.Lace.14489
Dendrelaphis caudolineatus: MZB.Ophi.6162
Eutropis multifasciata: MZB.Lace.14492, MZB.Lace.14493
Gonocephalus liogaster: MZB.Lace.14486, MZB.Lace.14487
Hemiphyllodactylus typus: MZB.Lace.14491
Homalopsis buccata: MZB.Ophi.6161
Lycodon subannulatus: MZB.Ophi.6164 (labeled as *Dryocalamus subannulatus*)
Lygosoma samajaya (labeled as *Lygosoma* sp.): MZB.Lace.14488
Sphenomorphus cyanolaemus: MZB.Lace.14490